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AN INDEX OF THE PHYSICAL VOLUME OF PRODUCTION

EDMUND E. DAY

IV. AGRICULTURE, MINING, AND MANUFACTURE COMBINED, 1899–1919

THE SIGNIFICANCE OF THE COMBINED INDEX

At several points in this study of the physical volume of production intimations have been given that an attempt would be made to develop an index for industry as a whole. For reasons which should now be clear, the construction of separate indices for agriculture, mining, and manufacture seemed a necessary and desirable preliminary step in the derivation of a more inclusive index. But now that the three separate indices are at hand, and the nature of the variations of production in the major lines of economic endeavor is thoroughly understood, the way is clear for the construction of a general index of the physical volume of production.

It should not be thought that this general index is inclusive of all production. Production comprehends the rendering of valuable services, as well as the increase of valuable goods. Furthermore, it includes the manifold activities of trade and transport, of commerce and finance. These services are productive in that they are essential under modern methods in bringing goods to the consumer. But they do not directly contribute to the material and form of the articles of commerce. In brief, agriculture and mining provide the raw stuffs of which consumable goods are made; manufacture adapts the form of the material to human needs; trade and transport hold the goods for such times and convey them to such places as market forces compel. All of these lines of economic endeavor are included in current production; but there is special significance in those lines of production which yield the material and form of goods. Agriculture, mining, and manufacture seem more intimately connected with the physical volume of production than trade and transport, or commerce and finance. The combined index, while not inclusive of all production, is indicative of those elements of production in which physical volume is especially significant.

UNADJUSTED COMBINED INDEX

An index for agriculture, mining, and manufacture combined is readily obtained from the separate indices already constructed. Both unadjusted and adjusted indices are at hand for the twenty-one-year period from 1899 to 1919. An unadjusted combined index is secured by calculating a weighted geometric mean of the three separate indices for each year of the period. The weights employed correspond to the aggregate values of production in agriculture, mining, and manufacture during the census year 1909.[1] The unadjusted combined index, like the separate unadjusted indices, expresses production as a relative of the average annual production of the five-year base period 1909–13. The index, thus derived, appears in Table XXXIV and Chart XXXI.

While the method of weighting agriculture, mining, and manufacture according to aggregate values in 1909 is quite consistent with the method of weighting employed elsewhere in the study, and is presumably preferable at this point in the analysis to any other method of weighting, it is interesting to note the effect upon the combined index when the three components are weighted, not according to aggregate values, but according to the number of persons engaged, as reported in the census count of 1910. The numbers engaged in agriculture, mining, and manufacture respectively in that year were 12,384,000, 977,000, 8,101,000, and the corresponding weights to be employed in deriving the combined index are consequently 57, 5, and 38. The unadjusted combined index, calculated with these weights, is given in Table XXXIV. It will be observed that the indices obtained by the two systems of weighting are very much the same, despite the substantially different weights assigned to agriculture and manufacture under the two methods. The results are merely another illustration of the stability of index numbers under varying systems of logical weighting. Both methods of weighting the combined index are logical. But the method of weighting according to aggregate values seems more consistent with the significant relationships between agriculture, mining, and manufacture, and has the merit of following the precedent set in the combinations of other series in the present study.

Both tabular and graphic presentations of the unadjusted combined index disclose the features one might naturally expect in view of the method of obtaining the index. The movements of the combined index are not as markedly cyclical as those of the indices for mining and manufacture, but decidedly more cyclical than the fluctuations of the index for agriculture. The index brings out clearly the high production of the years 1905–07, 1912, and 1916–18. It throws into relief also the markedly low production of 1901, 1903, 1908, 1911, and 1914. A large general increase in the physical volume of production from 1899 to 1919 is clearly demonstrated by the index. This growth furnishes convincing evidence of the rapid economic development of the country.

THE ADJUSTED COMBINED INDEX

The adjusted combined index follows as readily as the unadjusted the separate indices for agriculture, mining,

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[1] These aggregate values and the proportionate weights are as follows:

	Unit = $1,000,000	Weight
Value of all agricultural products	5,487	36
Value of all mineral products	1,238	8
Value added by all manufacture	8,529	56
	15,254	100

Table XXXIV. — Unadjusted Indices of Agriculture, Mining, and Manufacture, and of the Three Combined

(*Arithmetic average for 1909–13 = 100*)

Table XXXV. — Adjusted Indices of Agriculture, Mining, and Manufacture, and of the Three Combined

(*Ordinates of Secular Trend = 100*)

Table XXXVI.—Annual Series Commonly Held Indicative of Physical Volume of Production

Year	Agri-culture	Mining	Manu-facture	Agriculture, Mining, and Manufacture, Combined		Agri-culture	Mining	Manu-facture	Agriculture, Mining, and Manufacture, Combined		Railway [a] freight tonnage (*Unit: million tons*)	Railway [a] net ton-miles (*Unit: billion ton-miles*)	Deflated bank clearings (*Unit: billion dollars*)	Year
				Weighted according to values in 1909	Weighted according to persons engaged in 1910				Weighted according to values in 1909	Weighted according to persons engaged in 1910				
1899	80.4	48.5	58.4	64.6	69.4	102.2	101.2	97.1	99.1	100.0	1013	132.6	44.98	1899
1900	80.9	51.3	59.0	65.4	70.1	100.3	97.4	91.7	95.3	96.8	1086	144.4	41.80	1900
1901	71.8	55.6	65.6	66.9	68.5	88.5	97.4	98.8	94.9	92.6	1144	152.2	49.34	1901
1902	91.4	59.5	72.1	77.3	81.8	108.0	97.7	105.3	105.5	106.4	1252	165.2	49.05	1902
1903	84.4	65.5	73.3	76.4	79.0	97.5	99.6	101.8	100.4	99.6	1307	173.8	50.87	1903
1904	93.3	66.1	71.9	78.5	83.1	105.6	94.4	95.8	99.4	101.6	1369	180.5	51.12	1904
1905	94.5	78.4	84.3	87.3	89.6	104.8	105.4	107.0	106.1	105.8	1530	201.2	59.02	1905
1906	100.5	82.4	90.5	93.3	95.6	109.1	105.3	110.1	109.2	109.2	1714	226.2	62.80	1906
1907	90.4	90.2	91.3	90.9	90.8	96.5	109.2	107.2	103.2	100.8	1664	227.5	61.27	1907
1908	95.5	74.8	77.5	83.3	87.2	100.2	87.2	88.0	92.2	94.8	1545	218.6	58.04	1908
1909	95.0	91.9	95.4	95.0	95.0	97.8	101.0	102.9	101.0	100.0	1704	236.9	63.47	1909
1910	99.1	97.8	96.9	97.8	98.2	100.1	102.5	101.2	100.7	100.5	1816	254.4	66.79	1910
1911	94.1	94.3	92.4	93.2	93.5	94.0	95.2	92.7	93.5	93.7	1814	259.0	69.93	1911
1912	111.0	105.1	105.9	107.6	108.7	108.3	101.6	102.0	104.2	105.4	1952	282.9	71.96	1912
1913	98.2	110.2	109.2	105.2	102.8	94.2	102.5	102.5	99.1	97.4	2017	295.2	73.59	1913
1914	108.5	98.3	100.1	102.9	104.7	102.6	88.9	91.6	95.7	98.1	1889	282.8	70.81	1914
1915	113.4	110.4	109.3	110.8	111.7	106.3	96.1	96.7	100.2	102.1	2014	310.3	75.69	1915
1916	100.4	129.5	127.7	117.2	111.4	92.3	109.4	111.2	104.0	100.1	2316	366.2	80.71	1916
1917	108.5	134.5	125.6	119.8	115.9	98.6	109.5	106.2	103.8	102.2	2418	398.3	71.94	1917
1918	107.1	135.6	125.0	119.0	114.9	96.1	107.1	103.9	101.4	99.6	2418	403.8	76.64	1918
1919	110.6	110.8	114.0	112.5	111.9	98.2	85.2	91.1	93.0	94.7	....	....	84.48	1919

a. Calendar year figures used for 1899–1915 are averages of the figures for the fiscal years ending June 30 and beginning July 1. The 1916 figure for railway freight tonnage was reported by the Interstate Commerce Commission; 1917 and 1918 are estimated based upon data from the same source. Calendar year figures of net ton-miles for the years 1916–18 are taken from the reports of the Railroad Administration.

and manufacture. The adjusted index is a weighted arithmetic mean of the three separate indices. Weighting is again according to aggregate values in 1909, though for purposes of comparison, the index obtained by weighting according to the number of persons engaged in 1910 has also been derived. The adjusted combined index, obtained by this simple method, is given in full in Table XXXV and shown graphically in Chart XXXII.

The adjusted combined index naturally resembles the adjusted indices for mining and manufacture more than it does the adjusted index for agriculture. The index exposes clearly the course of the successive cycles marking the period from 1899 to 1919. The years 1902, 1905–07, 1912, 1916–17, were years of especially large production; 1900–01, 1908, 1911, 1914, and 1919, years of particularly low production. The index registers strikingly the ups and downs of economic activity in the country, and shows in simple fashion the extent to which, from the point of view of production, the later war years were like a period of high prosperity and boom such as features regularly the culminating stages of business cycles in the United States.

Comparison of Combined Indices with Three Significant Annual Series

Two annual series are commonly cited as particularly significant of the physical volume of business in the United States. These series are *deflated bank clearings, exclusive of New York City*, and revenue *net ton-miles* on the railroads of the country. Another series is to be considered in the same connection: *freight tonnage* handled by the railroads. Bank clearings as originally recorded are not indicative of the volume of business over considerable periods because of the influence of changes in the price level; but this disturbing element is eliminated when aggregate bank clearings are divided by a price index. For the purpose of deflation, the price index of the United States Bureau of Labor has been employed. Deflated outside bank clearings, thus obtained, and railway net ton-miles and freight tonnage, for the years from 1899 to 1919, are given in Table XXXVI.

To enable direct comparison of these series with the unadjusted combined index, the three annual series have been reduced to relatives of their respective averages for the base period 1909–13. The resultant relatives are shown in Table XXXVII. They also appear in Chart XXXIII. Comparison of these relatives of the three annual series with the combined unadjusted index shows that, in the element of growth, the series of deflated outside bank clearings is most nearly like the combined index. In respect to the year-to-year fluctuations, however, the series for freight tonnage is obviously the one most closely resembling the combined index. This is quite consistent with the general nature of the three annual series; for both deflated outside bank clear-

TABLE XXXVII. — THREE SIGNIFICANT ANNUAL SERIES EXPRESSED AS RELATIVES OF FIXED BASE

(*Average for 1909–13 = 100*[b])

Year	Railway freight tonnage	Railway net ton-miles	Deflated bank clearings
1899	54.4	49.9	65.0
1900	58.4	54.4	60.4
1901	61.5	57.3	71.4
1902	67.8	62.2	71.0
1903	70.2	65.4	73.6
1904	73.6	67.9	74.0
1905	82.2	75.7	85.4
1906	92.1	85.1	90.8
1907	89.4	85.6	88.6
1908	83.0	82.3	84.0
1909	91.6	89.1	91.8
1910	97.6	95.8	96.6
1911	97.5	97.5	101.1
1912	104.9	106.4	104.0
1913	108.4	111.0	106.3
1914	101.5	106.4	102.4
1915	108.2	116.8	109.5
1916	124.4	137.8	116.7
1917	129.9	149.9	104.0
1918	129.9	151.8	110.8
1919	....	....	122.2

TABLE XXXVIII. — THREE SIGNIFICANT ANNUAL SERIES EXPRESSED AS RELATIVES OF ORDINATES OF SECULAR TREND

(*Ordinates of Secular Trend 1899–1913 = 100*[c])

Year	Railway freight tonnage	Railway net ton-miles	Deflated bank clearings
1899	97.4	101.1	104.7
1900	97.8	101.4	92.4
1901	97.0	99.0	104.0
1902	100.2	100.1	99.0
1903	99.2	98.6	98.4
1904	98.6	96.3	94.8
1905	104.9	101.2	105.2
1906	112.2	107.7	107.7
1907	104.2	102.8	101.5
1908	92.7	94.0	92.7
1909	98.2	97.2	98.0
1910	100.6	99.8	99.7
1911	96.8	97.3	100.7
1912	100.4	101.9	100.8
1913	100.1	102.2	100.2
1914	90.6	94.2	93.5
1915	93.5	99.7	97.2
1916	104.2	113.5	100.7
1917	105.4	119.3	87.5
1918	102.4	117.0	90.8
1919	....	....	97.6

TABLE XXXIX. — CYCLES OF COMBINED INDEX AND OF THREE SIGNIFICANT ANNUAL SERIES

(*Ordinates of Secular Trend = 0*)

Combined index	Railway freight tonnage	Railway net ton-miles	Deflated bank clearings	Year
− .2	− .6	+ .4	+1.2	1899
−1.1	− .5	+ .4	−1.8	1900
−1.1	− .7	− .3	+ .9	1901
+1.3	.0	.0	− .2	1902
.0	− .2	− .4	− .5	1903
− .2	− .3	−1.2	−1.2	1904
+1.3	+1.1	+ .4	+1.2	1905
+1.9	+2.8	+2.5	+1.8	1906
+ .6	+1.0	+ .9	+ .5	1907
−1.7	−1.7	−1.9	−1.6	1908
+ .2	− .4	− .9	− .5	1909
+ .2	+ .1	− .1	.0	1910
−1.3	− .7	− .9	+ .2	1911
+ .9	+ .1	+ .6	+ .2	1912
− .2	.0	+ .7	.0	1913
− .9	−2.2	−1.8	−1.4	1914
.0	−1.5	− .1	− .7	1915
+ .9	+1.0	+4.3	+ .2	1916
+ .9	+1.3	+6.1	−3.0	1917
+ .2	+ .6	+5.4	−2.0	1918
−1.5	....	....	− .5	1919

[b] The averages for the three series for 1909–13 are as follows: railway freight tonnage, 1861 million tons; railway net ton-miles, 265.7 billion ton-miles; deflated bank clearings, 69.15 billion dollars.

[c] The equations for secular trend for the three series are as follows: railway freight tonnage, $y = 69.64x + 1527$; railway net ton-miles, $y = 11.26x + 210.0$; deflated bank clearings, $y = 2.176x + 58.27$.

ings and railway net ton-miles are influenced by the volume of trading as well as by the physical volume of goods traded. Freight tonnage, upon the other hand, is not affected in as large a degree by trading activity, and corresponds more closely to the physical volume of goods produced in agriculture, mining, and manufacture. Probably no other simple annual series as closely parallels the combined index.

This conclusion is confirmed when the three annual series are compared with the combined *adjusted* index. Comparison in this case necessitates the derivation of the lines of secular trend of the three annual series. If the yearly items in each of the three annual series are expressed as percentages of their respective ordinates of secular trend, the resulting percentage relatives are directly comparable with the yearly items of the combined adjusted index. Percentage relatives obtained in this fashion for each of the three annual series are given in Table XXXVIII; and, in terms of percentage deviations above and below 100, are shown in Chart XXXIV.

At many points the similarity of the series is striking. But again there is no question as to which of the three annual series most closely resembles the index for agriculture, mining, and manufacture combined. During the pre-war period the series follow somewhat the same course, but during the war years railway net ton-miles go to extraordinarily high relative figures, deflated bank clearings to extraordinarily low. Railway freight tonnage alone follows a course during the war closely paralleling that followed by the combined index.

Comparison of the three annual series with the combined index may be concluded with an examination of the cycles of the index and the three series. These cycles are given in Table XXXIX. The clear correspondence of the series of freight tonnage with the combined index again leads to the conclusion that freight tonnage is more significant of the physical volume of production than either net ton-miles or deflated bank clearings. The coefficients of correlation between the combined index and the three annual series are as follows:

Deflated bank clearings....................	+.57
Railway net ton-miles......................	+.70
Railway freight tonnage....................	+.87

It is clear enough that railway freight tonnage is distinctly the best single-series barometer of the physical volume of agriculture, mining, and manufacture combined. Railway net ton-miles and deflated bank clearings are more inclusive series, influenced by the volume of trading as well as by the physical volume of goods traded.

The present study of the physical volume of production has now covered the ground mapped out at the start. In a measure, the analysis has been but a preliminary survey of a field of investigation promising splendid returns to more intensive cultivation. But inconclusive as some of the results may appear, the analysis has disclosed many points of obvious significance in the study of the nation's income of producers' and consumers' goods, and the general course of the business cycle. To confirm and complete the picture, the tentative results thus far obtained must be carefully tested in the light of accumulating data, and analysis must be extended to those fields of activity — such as trade and transport — not included in the present study. Persistent effort along these lines will in time surely contribute to that fuller understanding of the physical elements of industrial life so much needed in the solution of pressing economic and social problems.[1]

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[1] In bringing this study to a close, the author wishes to acknowledge his heavy indebtedness to the members of the staff, and in particular to Eunice S. Coyle and Ester I. Fismer for indispensable assistance upon the sources and nature of data; to Ada M. Matthews and Dorothy Pease for indefatigable work upon the computations; and to Edwin Frickey for invaluable aid in the auditing of methods and results.

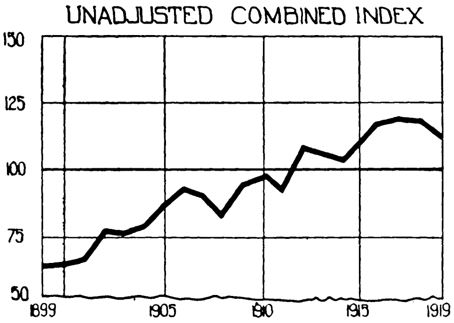

Chart XXXI. — Unadjusted Index for Agriculture, Mining, and Manufacture Combined. (*Average 1909–13 = 100*)

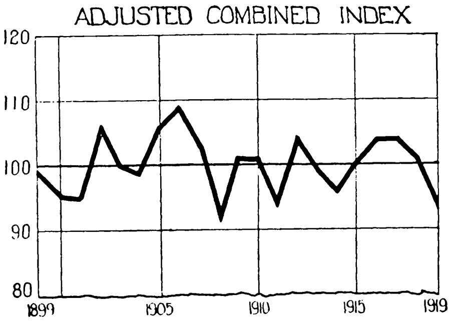

Chart XXXII.—Adjusted Index for Agriculture, Mining, and Manufacture Combined. (*Ordinates of Secular Trend = 100*)

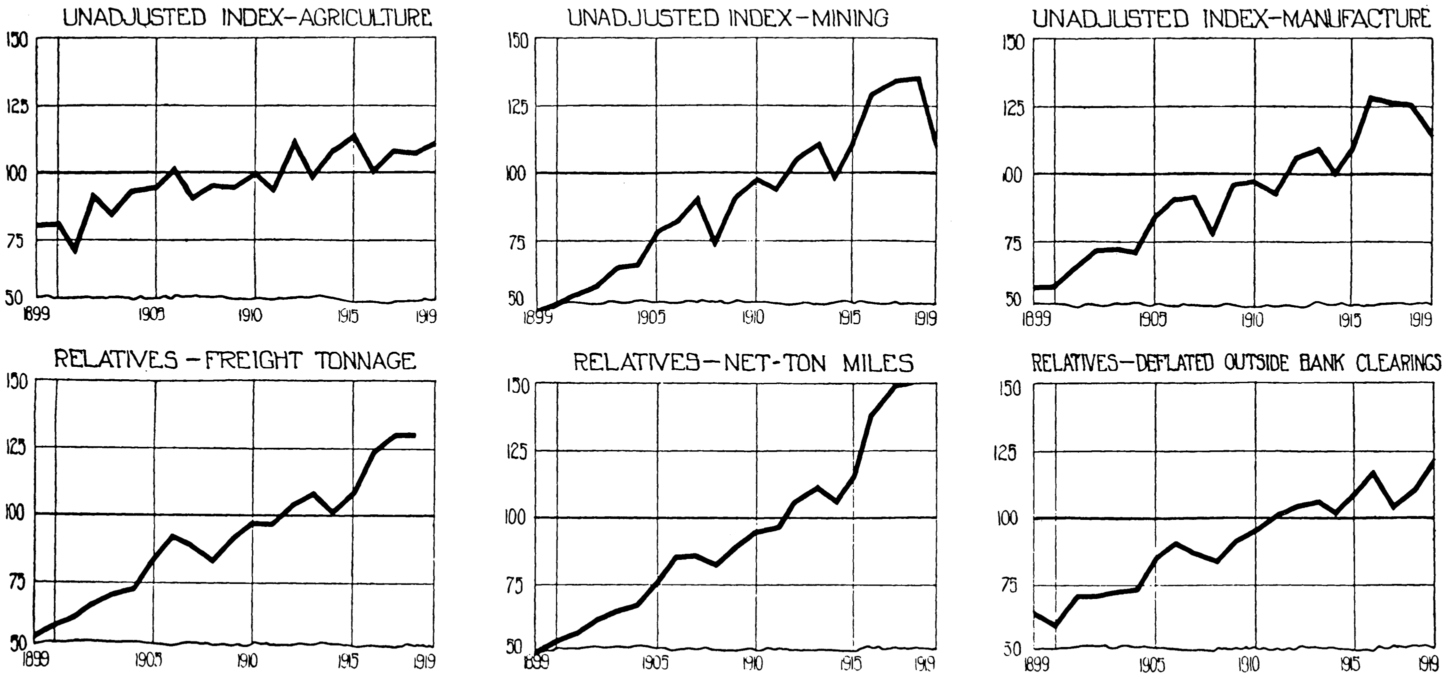

Chart XXXIII. — Unadjusted Indices for Agriculture, Mining, and Manufacture; and Percentage Relations of Freight Tonnage, Net Ton-Miles, and Deflated Outside Bank Clearings. (*Average 1909–13 = 100*)

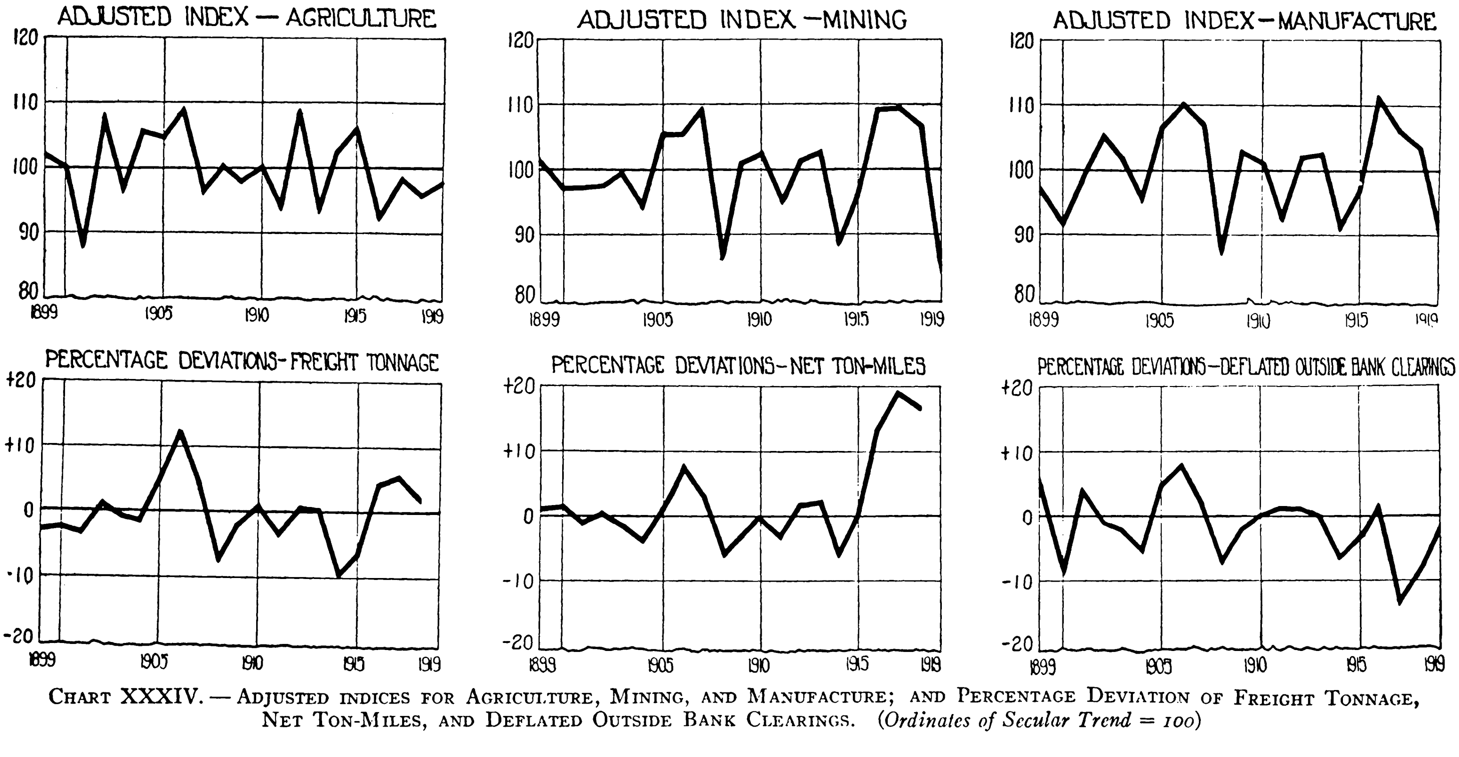

Chart XXXIV. — Adjusted indices for Agriculture, Mining, and Manufacture; and Percentage Deviation of Freight Tonnage, Net Ton-Miles, and Deflated Outside Bank Clearings. (*Ordinates of Secular Trend = 100*)